



Jet Propulsion Laboratory
California Institute of Technology

Planetary Small Spacecraft

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August 4, 2016

Why Planetary CubeSats?

Perform focused planetary science while demonstrating new instruments and small spacecraft capabilities for future planetary missions.

Go new places



Increase the frequency of Science missions

Validate instrument and S/C technologies

Planetary Decadal Science Mapping and Instrument Availability

THEME	KEY MEASUREMENTS	OBSERVATION STRATEGY	NANOSAT-COMPATIBLE INSTRUMENTS
Origins	Isotopic, elemental, mineralogical composition	In situ (atmospheres, surface)	APXS, TLS, IR spec, Raman, LIBS Submm spec, UV Spec, Gamma ray spec, Dust spec, MassSpec
		Returned sample (small bodies)	Sample Return Capsule (possibly Acquisition as well)
Planetary Habitats	Volatile, organics composition, endogenic activity, heat budget, env	In situ, distributed network, subsurface (e.g., penetrators)	MassSpec, micro-XRF, Geophysics Inst., imaging, IR spec, seismometer
Processes	Atmospheric structure, dust, fields, geology	Close proximity, in situ, distributed networks	Cameras, IR spec, Mag, Transponders, Langmuir probes, MassSpec, TLS, dust counter, plasma
Human Exploration (SKGs)	Dust, fields, radiations, Dynamical properties, Mechanical properties, ISRU (composition)	Close proximity, in situ, extreme environments	Dust Counter, imaging, APXS, Geophysics Inst., accelerometers Subsurface probing, neutron spec, IR spec, radar, seismometer

code: Green = exists Orange = in development Red = does not exist yet

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New Science Grade Instrument Capabilities

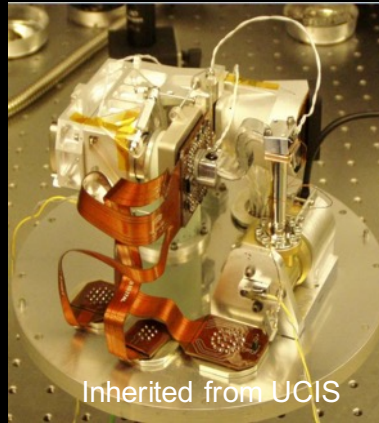
QIT-MS
JPL



**Quadrupole Ion Trap
Mass Spectrometer**

2.5 kg, 2U, isotopic accuracy <1%, leverages foldable edge-connected electronics

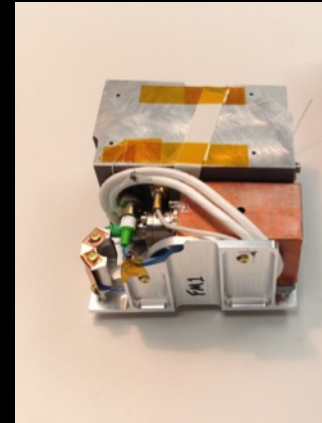
SWIS
JPL



Snow and Water Imaging Spectroscopy

High-throughput, low-polarization, high-uniformity spectrometer, 350-1700 nm spectral range

MAG
JPL



Advanced Vector Helium Magnetometer

Comparable performance to Cassini magnetometer (Now being used by Europa)

IntelliCam
JPL



High-Resolution Visible Camera

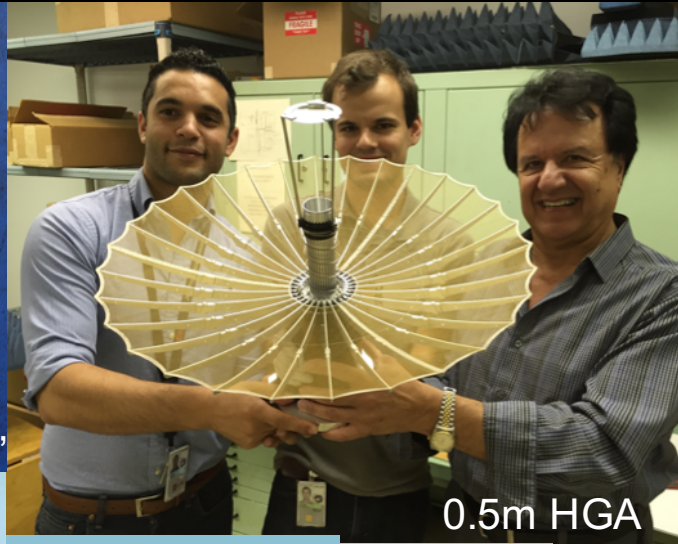
Used for science, optical navigation, and Autonomous Navigation demonstration

Tested/developed for cubesats, extensible to larger missions

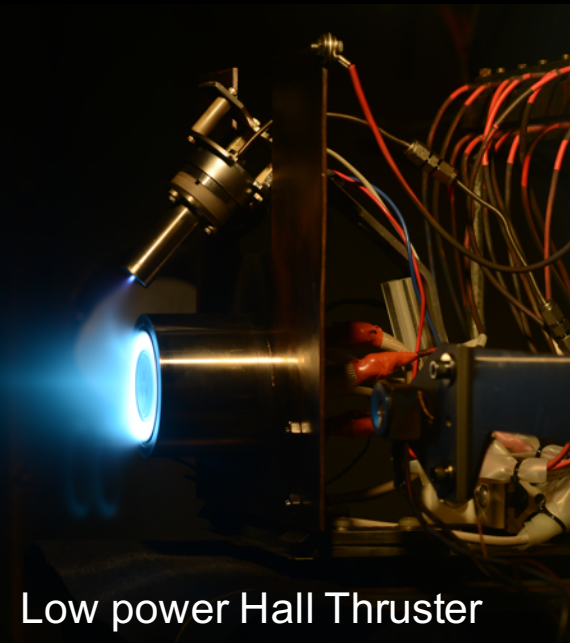
Current Capabilities and Investments for innovative missions



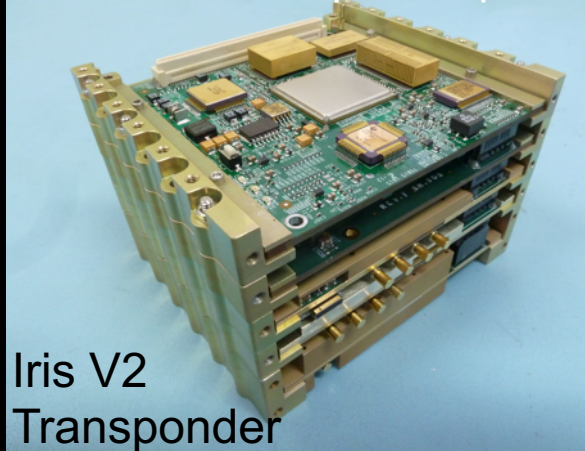
LEON 3FT Computer 'Sphinx'



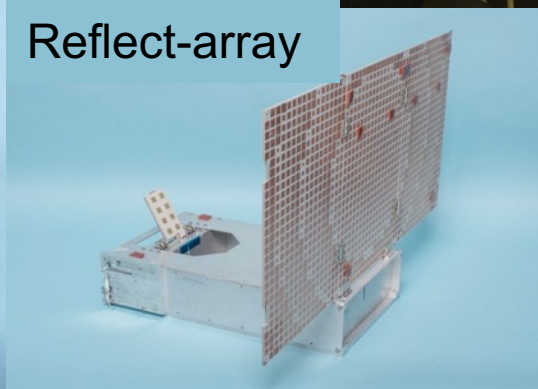
0.5m HGA



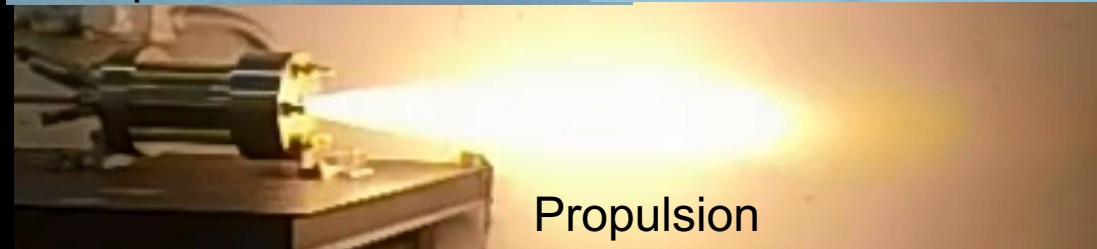
Low power Hall Thruster



Iris V2
Transponder



Reflect-array



Propulsion



Cold gas/
Green prop

WAITING FOR LAUNCH

IN DEVELOPMENT

RADIO
& DSN
SUPPT

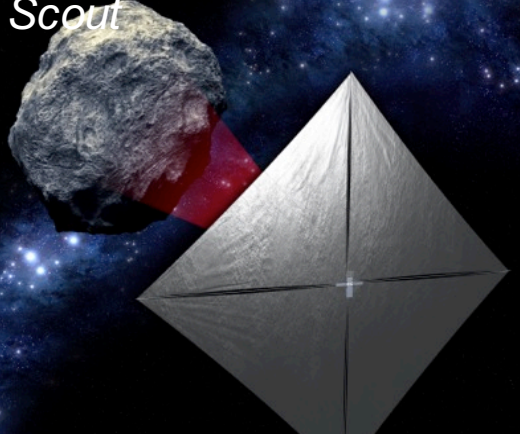
INSPIRE
Interplanetary NanoSpacecraft Pathfinder In a Relevant Environment
 Low-cost mission leadership with the world's first CubeSat beyond Earth-orbit
 PI: Dr. Andrew Klesh, Jet Propulsion Laboratory
 PM: Ms. Lauren Holatek, Jet Propulsion Laboratory
 University Partners:
 • U. Michigan – Ann Arbor
 • Cal Poly – San Luis Obispo
 • U. Texas – Austin
 • U. California – Los Angeles
 Collaborator:
 • Goldstone-Apple Valley Radio Telescope (GAVRT)



Mag, Comm & Nav Demo

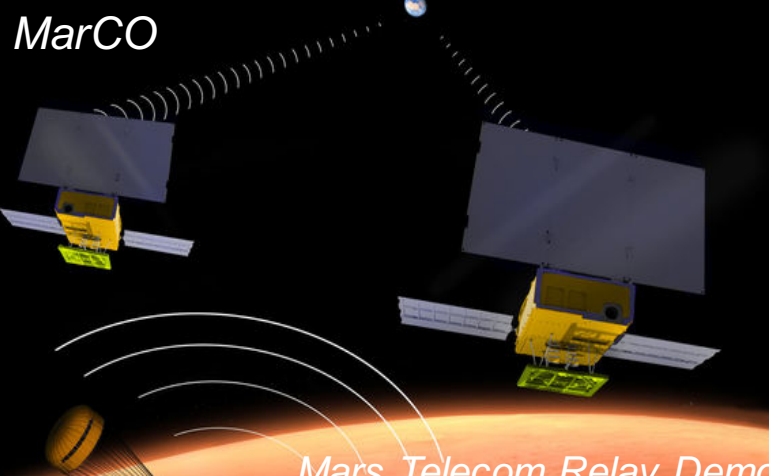
UNIVERSITY OF CALIFORNIA GAVRT CAL POLY TEXAS

NEA Scout



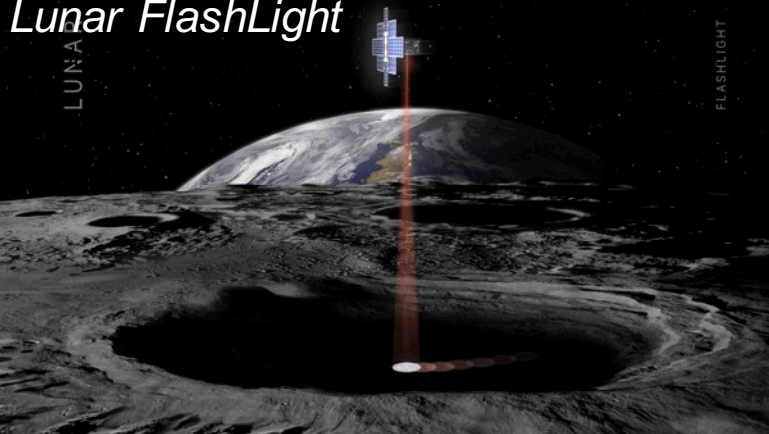
Characterize Asteroid

MarCO



Mars Telecom Relay Demo

Lunar FlashLight



Map Polar Surface Ice

Bio-Sentinel (ARC)

Lunar IceCube (MSU)

Luna-H (ASU)

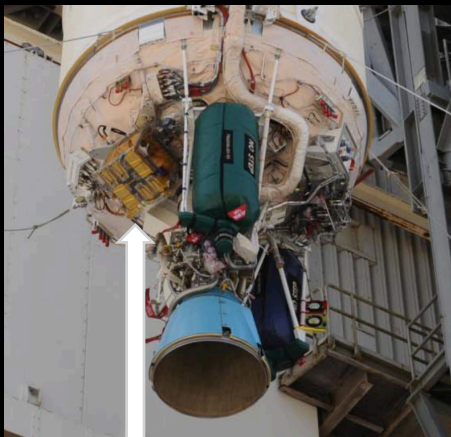
CuSSP (UCLA)

MSU DSN Ext

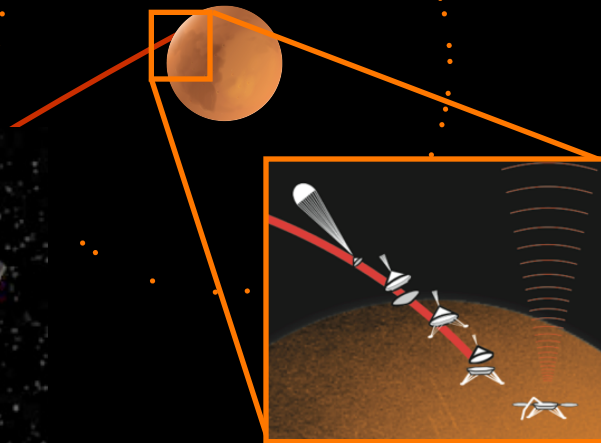
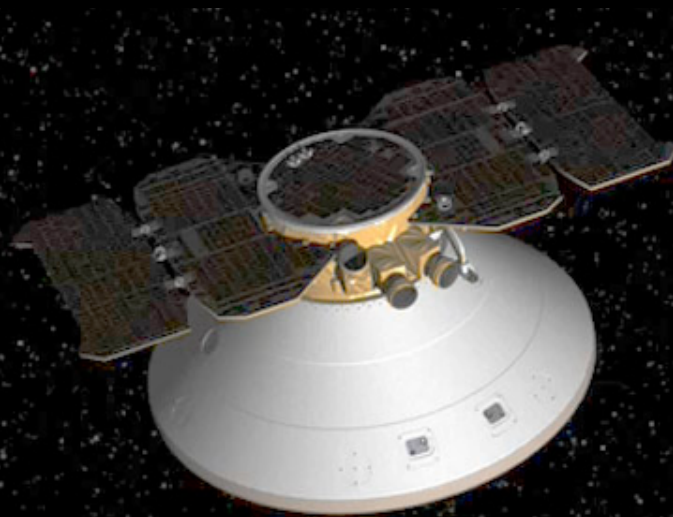
Pre-decisional - For Discussion Purposes Only

MarCO Requirements:

- Launch with Insight May 2018
 - Provide 8kbps real-time relay during Insight E Mars Flyby Trajectory
- 1 req'd, but fly 2

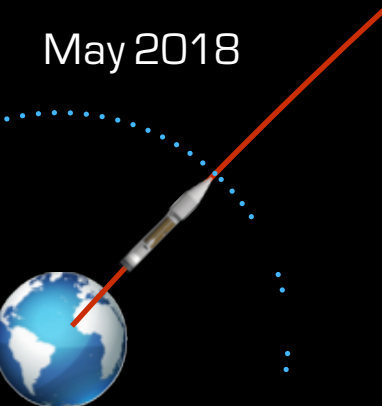


Aft Bulkhead Carrier
MarCO Location

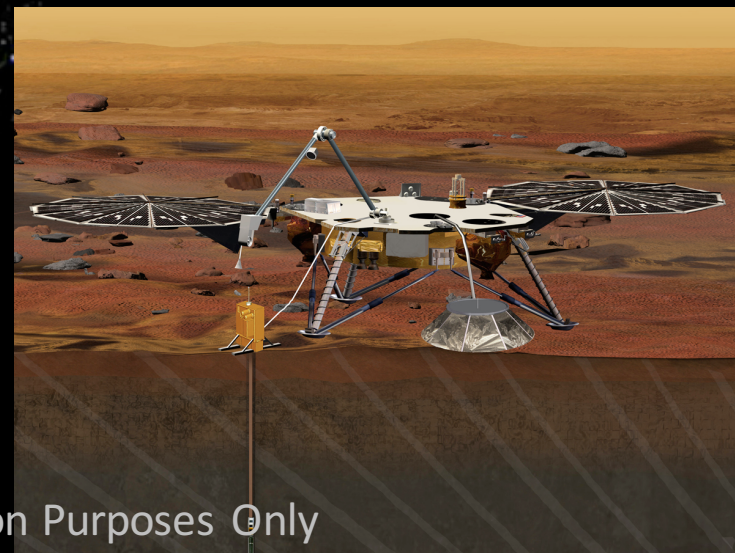


Entry, Descent, and Landing
Nov, 2018

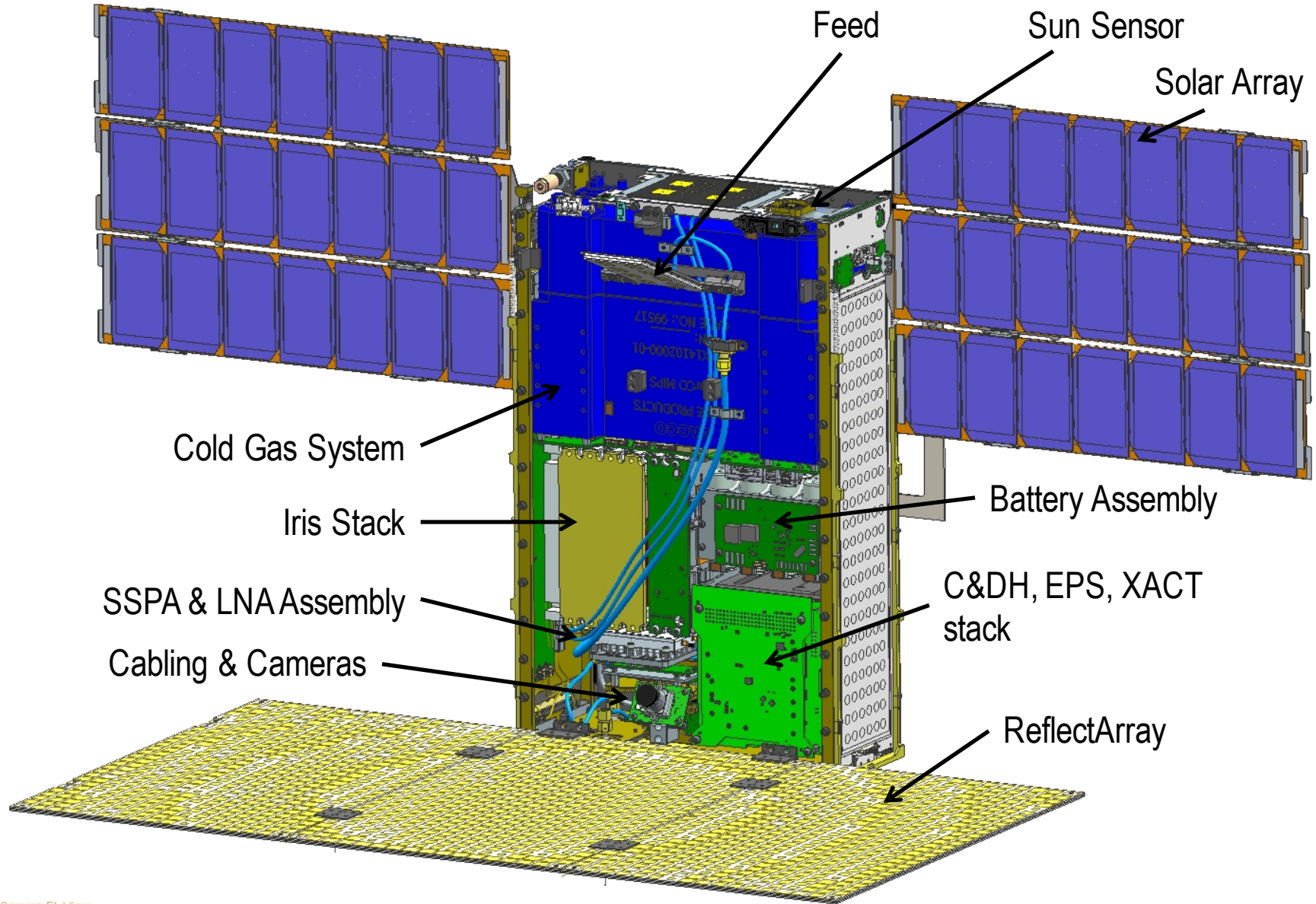
May 2018



Pre-decisional - For Discussion Purposes Only

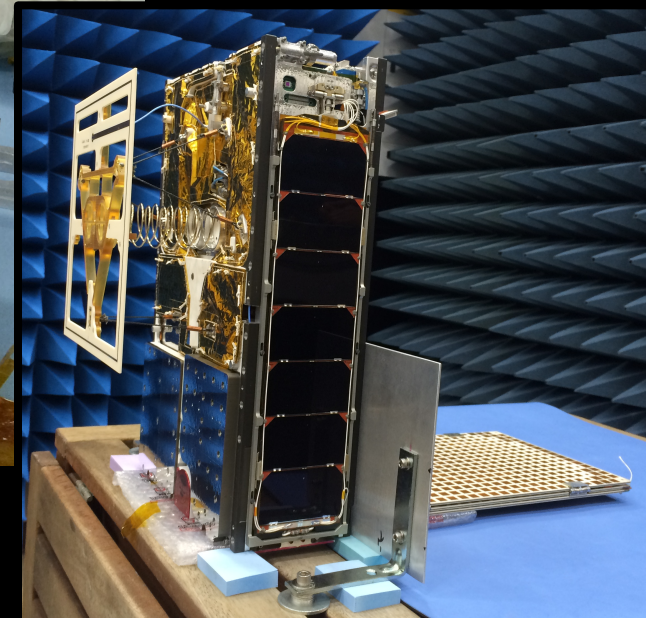
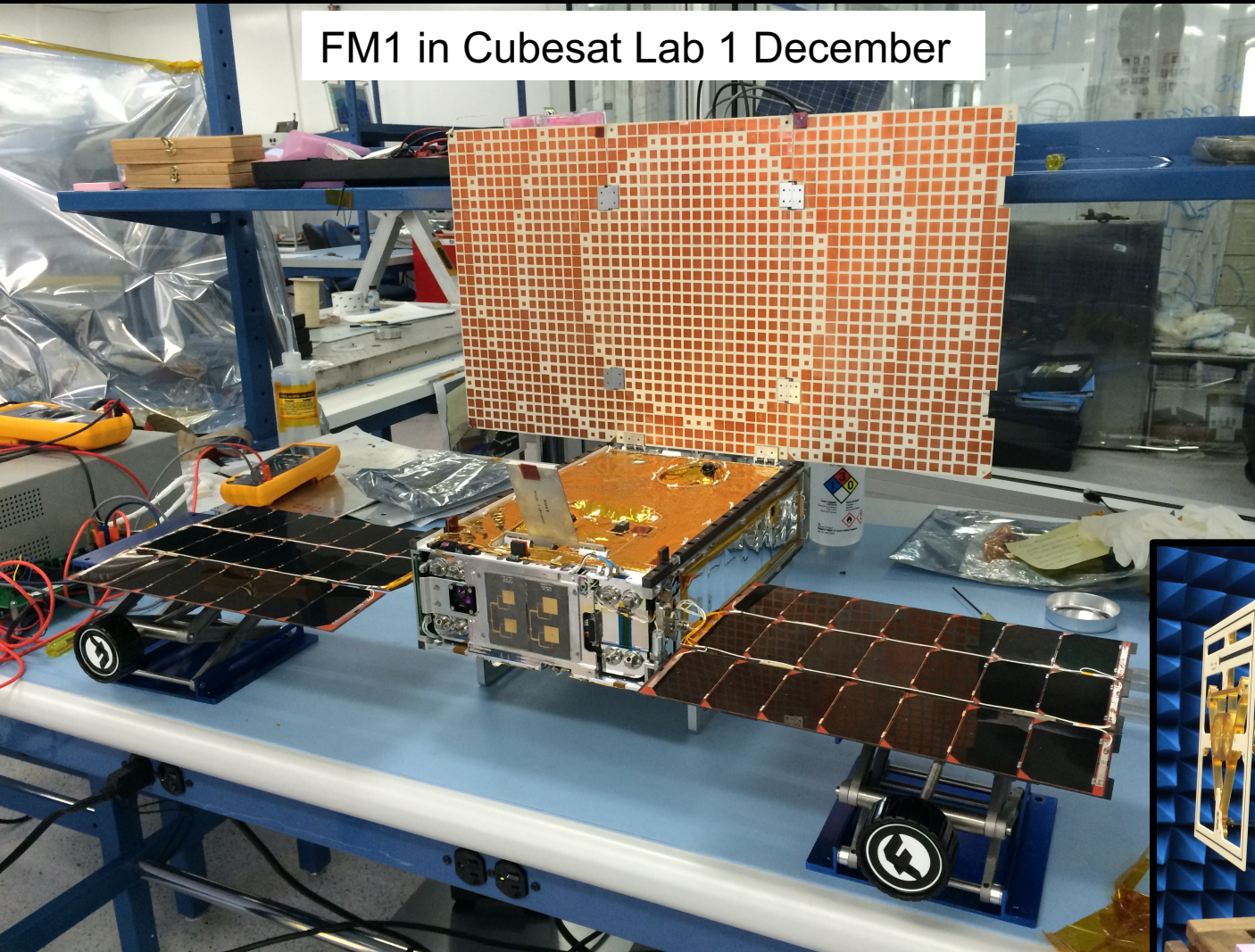


MarCO Mechanical Configuration: Deployed



MarCO FM1 post-Vibe

FM1 in Cubesat Lab 1 December



Pre-decisional - For Discussion Purposes Only

Questions about CubeSats at JPL

- Can Cubesats even do science?
- Should we even be in the business at all?
- Does working on CubeSats train young engineers to learn the wrong things?
- Should we do in-house work?
- Does working on CubeSats advance your career?
- Why isn't Lockheed Martin working on CubeSats?



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jpl.nasa.gov/cubesat